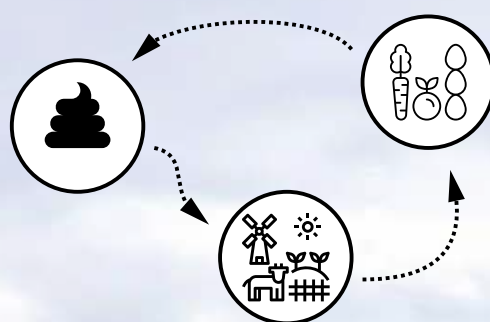




THE UNIVERSITY OF BRITISH COLUMBIA

Beneficial Recirculation of Nutrients and Organic Matter to Agriculture

Meeting the Needs of Farmers and Soils



Beneficial Recirculation of Nutrients and Organic Matter to Agriculture: Meeting the Needs of Farmers and Soils.

The research underpinning this report was conducted as part of the postdoctoral research visit of

Dr. Robin Harder

to the

Sustainable Agricultural Landscape Laboratory

at the

University of British Columbia.

This visit was supported by a mobility starting grant from

Formas - Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning

under grant agreement

2016-00859

and with project title

Recycling organic matter and nutrients from sanitation to farming systems to regenerate soil and land: identifying approaches that are feasible *and* preferable.

The work was supervised by

Dr. Sean Smukler

as part of the project

Organic Vegetable Nutrient Management in British Columbia

with funding provided by the

Organic Science Cluster 3.



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

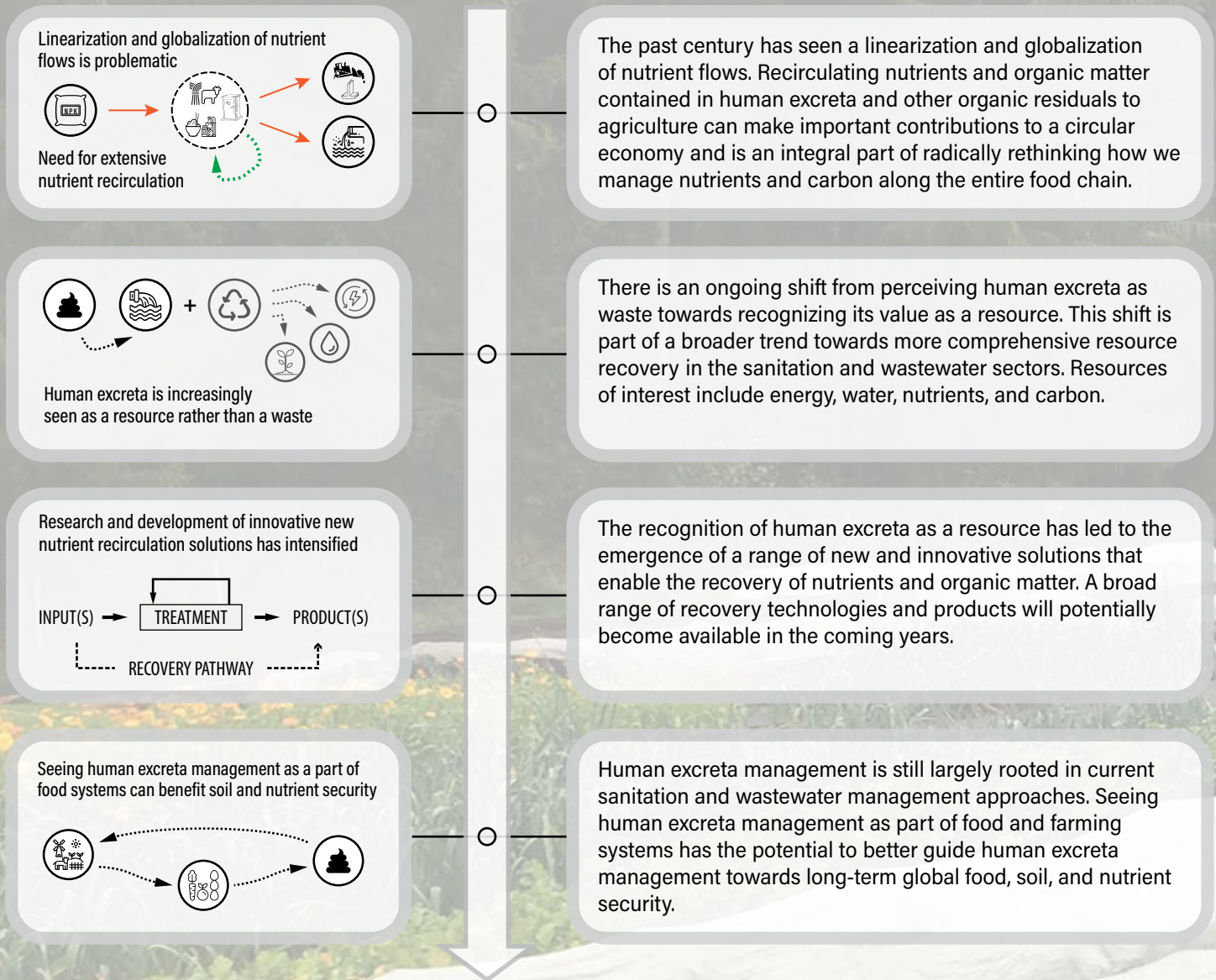
We are grateful to the participating BC organic vegetable producers for their time and for sharing with us their stories, knowledge, and opinions.

This study has been approved by the UBC Behavioral Research Ethics Board (UBC BREB H18-00140).

SUMMARY

In April 2018, we set out to learn from 10 organic vegetable producers in British Columbia about their perspectives on new and innovative fertilizer products rendered by the treatment of human excreta (i.e. urine and feces), wastewater, and other organic residuals. This report summarizes the findings from the interviews we conducted and is a part of a larger project designed to bring a greater understanding of various alternative nutrient sources, and improve their utilization.

PROJECT BACKGROUND AND SCOPE



Interviews with 10 organic vegetable producers in British Columbia



April 2018

10
Farms



How can alternative fertilizer products and soil amendments recovered from agricultural and urban residuals best support producers in their endeavours to grow healthy food and maintain long-term soil fertility and health?

CURRENT PERSPECTIVES ON FARM, SOIL, AND NUTRIENT MANAGEMENT



PERSPECTIVES ON FARM MANAGEMENT

Envision a farm that does things right and a farm that does things badly when it comes to managing nutrients and soil.

What does this farm do or not do?

THE 'GOOD' FARM

biodiverse, innovative, open to testing new approaches
avoidance of synthetic and chemical fertilizers



THE 'BAD' FARM

industrial approach, giant monocultures for global market
addiction to synthetic fertilizers and pesticides



GOOD PRACTICES

integrated animal-grass-crop production
cover cropping and sensible tillage practices
crop selection appropriate to season and region
regular field inspections and soil tests
thorough record keeping and equipment calibration
respects natural cues and the soil as living system



PERSPECTIVES ON THE 'GOOD' SOIL AND NUTRIENT INPUT

Let us now consider a hypothetical situation where we do not take into account any aspects to do with organic certification, other legislation, user perception, etc. We focus solely on the quality of your soils and produce.

What makes a good soil? What makes a good nutrient input?

THE 'GOOD' SOIL

SOIL AS LIVING ECOSYSTEM

- high levels of organic matter
- healthy microbiome that breaks down organic matter and makes things available to plants
- good natural fertility and nutrient holding capacity
- balance between good drainage and the capacity to hold moisture
- clean smell and taste and adequate texture
- salinity levels that are not excessive

capacity to make things grow

THE 'GOOD' NUTRIENT INPUT

affordable

meets nutrient needs

- availability
- composition
- release characteristics

easy to apply

sustainable

- on-farm production
- sustainable supply chain
- resilient towards over-application



CURRENT SOIL MANAGEMENT AT THE FARMS

What do you do to maintain or improve the state of your soils? How satisfied are you with the outcomes?

PRACTICES TO MAINTAIN AND IMPROVE SOIL STATUS*

■	9	cover cropping
■	6	minimal tillage
■	5	compost and manure application
■	5	liming

SATISFACTION WITH THE STATE OF YOUR SOILS

■	3	satisfied
■	6	quite satisfied, could be better
■	1	not satisfied

*Other practices: mulching, crop-livestock integration, crop rotation, fallowing, soil testing, drainage, learn where the water is.



CURRENT NUTRIENT INPUTS AT THE FARMS

What are currently the main nutrient inputs to your farm? How do you decide which nutrient inputs to apply and at which application rates? Do you have any concerns regarding adverse impacts of certain inputs?

NUTRIENT INPUTS

fish meal
feather meal
boron

KEY PRODUCTS



compost
manure
blood meal

Vancouver Island

Lower Fraser Valley

compost, manure
blood meal, bone meal
guano, alfalfa meal
ash, potash, seasoil

OTHER PRODUCTS

fish meal, feather meal
bone meal
insect frass
micronutrient mix

DECISION FACTORS

soil and crop needs	soil testing, crop requirements
experience	own experience, other farmers
infrastructure	machinery

CONCERNS

health	dust
quality	salt, weeds, pathogens, strings, twines
sustainability	overapplication of nutrients, dependence on industrial livestock operations



PERSPECTIVES ON THE AVAILABILITY OF NUTRIENT INPUTS

Currently, do you feel you have good access to nutrient inputs? Do you have concerns regarding future availability?

PERCEPTION OF CURRENT AVAILABILITY

sourcing is challenging
producers are at the whim of suppliers



Vancouver Island

Lower Fraser Valley

current availability of
nutrient inputs is good

CONCERNS REGARDING FUTURE AVAILABILITY

nutrient scarcity
P depletion
and
micronutrient scarcity

accessibility
geopolitical issues
and
price increases

regulations
more stringent
regulations on
use of manure

planning
lack of integrated
thinking around
nutrient flows

sustainability
nutrient mining
unsustainable in
the long run



PERSPECTIVES ON NUTRIENT INPUTS

Are there any inputs or practices you do not currently apply (enough) but would like to apply (more)? Which inputs and practices that you are aware would you not consider applying at your farm and why?

NUTRIENT INPUTS AND PRACTICES TO APPLY (MORE)

serenade	no-till	soil testing	make own compost	manure (chicken)	on-farm N fixation	cover crop integration	proactive application of micronutrients
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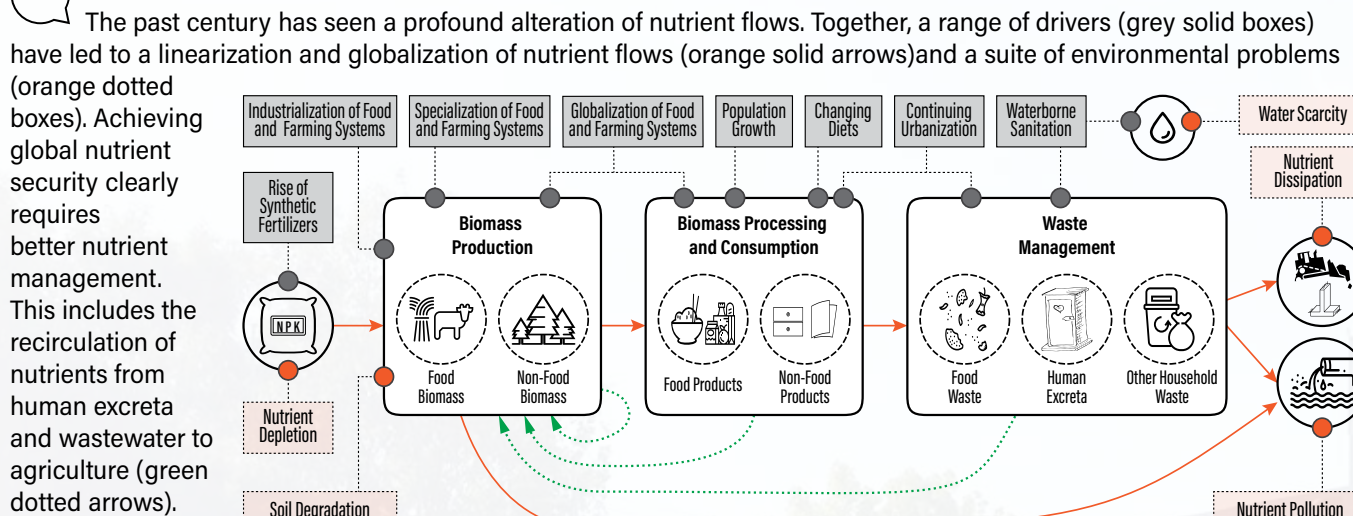
NUTRIENT INPUTS TO AVOID AND WHY

conventional fertilizers certification	humanure public perception and food safety	municipal green waste plastic pollution	foliar sprays needs large infrastructure	unsustainably sourced nutrients not viable in the long run
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BACKGROUND: WHY NUTRIENT RECIRCULATION AND WHAT ARE THE OPTIONS?



FROM LINEARIZATION AND GLOBALIZATION OF NUTRIENT FLOWS TO NUTRIENT RECIRCULATION

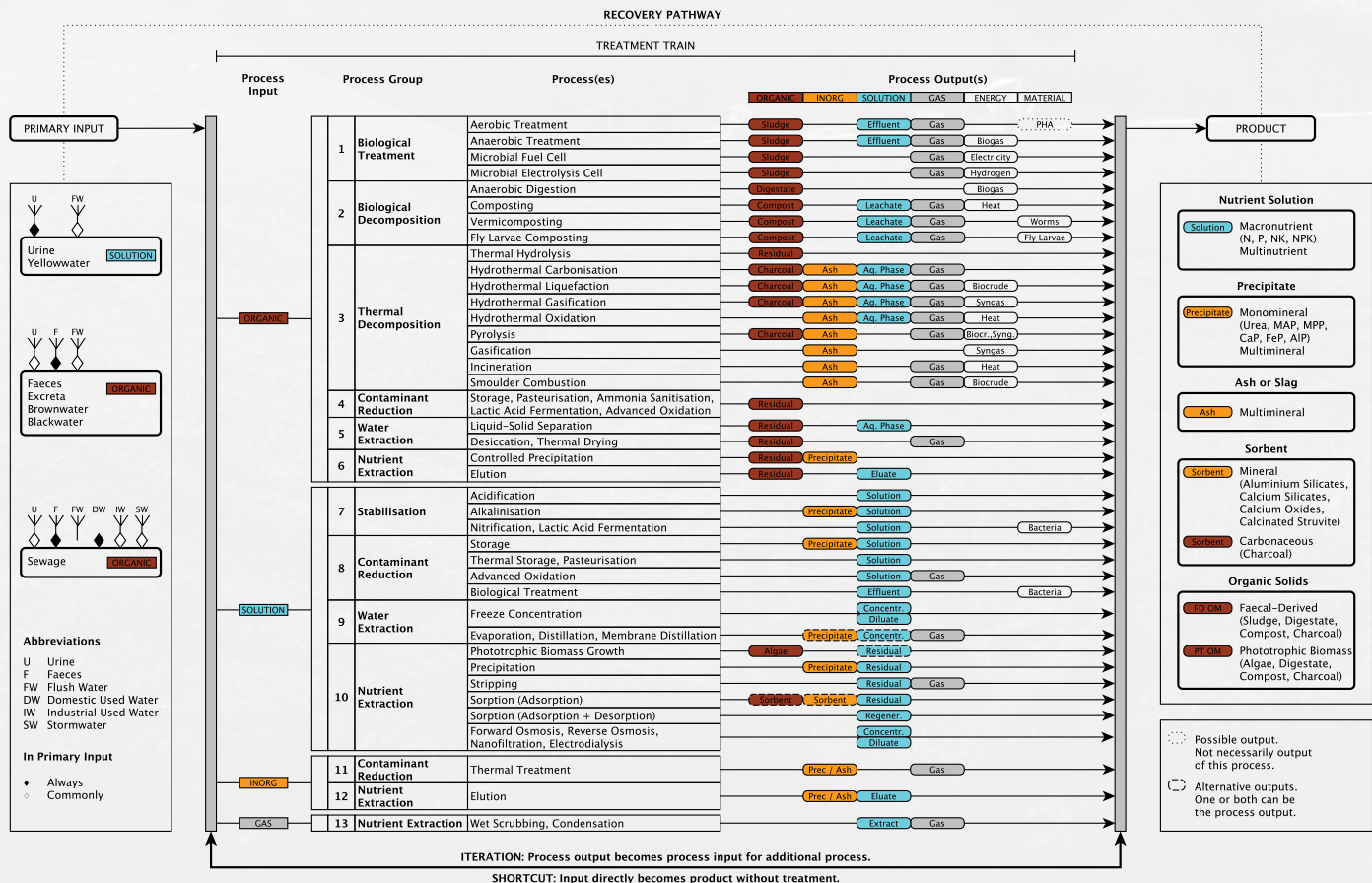


Source: Harder et al. 2020. Reframing human excreta management as part of food and farming systems.



RECOVERY OF NUTRIENTS AND ORGANIC MATTER IN SANITATION AND WASTEWATER MANAGEMENT

Over the past decades, a wealth of technologies that aim to facilitate the recovery and reuse of nutrients and carbon contained in human excreta, wastewater, and other organic residuals have unfolded.



Source: Harder et al. 2019. Recycling nutrients contained in human excreta to agriculture: Pathways, processes, and products.



BROAD CATEGORIES OF NUTRIENT-RICH PRODUCTS

Recycled fertilizers rendered through treatment of human excreta, wastewater, and other organic residuals can be grouped into five broad categories.

NUTRIENT SOLUTIONS



Example: Aurin

Nutrient solutions contain nutrients but are devoid of suspended organic matter. Some nutrient solutions can be used as fertilizers while others can be used as input for the production of fertilizers. Nutrient solutions that can be derived from human excreta or wastewater include concentrated urine and ammonium sulfate.

PRECIPITATES



Example: Struvite pellets

Precipitates range from slurries consisting of individual precipitated nuclei, which can be filtered and dried to obtain a powder, to larger crystals or granules. Common precipitates derived from human or wastewater include struvite (MAP) and potassium struvite (MPP), as well as, calcium, aluminum, and iron phosphates.

ASHES



Example: Ash pellets

Ashes and slags generally are not considered a product of direct use for agriculture unless subjected to additional treatment. Thermochemical treatment for instance renders calcinated ash that is potentially useful for agriculture. More commonly, ashes and slags are the starting point for the recovery of other fertilizer products such as struvite or the production of synthetic fertilizers.

SORBENTS



Example: Granular zeolite

A wide range of sorbents has been investigated to extract one or several of the macronutrients NPK from liquid streams. Sorbents can be broadly divided into two subgroups: carbonaceous and mineral sorbents. The main carbonaceous sorbent is charcoal. Key mineral sorbents include calcinated struvite as well as aluminum silicates, calcium silicates, or calcium oxides.

ORGANIC SOLIDS



Example: Biosolid compost

Fecal-derived organic solids include a wide variety of products that contain organic matter originating from feces or biomass produced during treatment of fecal-derived organic matter. Biological decomposition renders digestate or compost (including vermicompost and fly larvae compost), thermal decomposition renders charcoal.



Example: Dried ground algae

Phototrophic algae and cyanobacteria can be grown in urine and other liquid streams such as treated effluent, anaerobic digester supernatant, or the aqueous phase after hydrothermal liquefaction of feces. Algal biomass is a promising product potentially useful as plant fertilizer or animal feed.

FUTURE POTENTIAL FOR FERTILIZERS FROM ALTERNATIVE SOURCES



RECYCLED FERTILIZERS DERIVED FROM HUMAN EXCRETA AND WASTEWATER

Together with the producers, we discussed different alternative nutrient inputs. We asked the producers why they would or would not consider using certain alternative nutrient inputs on their farms.

OVERALL RESPONSE

Producers were very aware of the need to at some point use recycled fertilizers derived from - among other sources - human excreta and wastewater.

No clear preference for one type of recycled fertilizer. Rather, it seemed that the full range of potential recycling fertilizers could be useful.

KEY HINDRANCES

- acceptance and public perception
- regulations and standards
- lack of trust in waste management

KEY CONCERNS

- quality and pollutants
 - pathogens
 - antibiotics
 - medicines
 - hormones
 - metals
 - salts
- smell
- similarity to mineral fertilizers

PRODUCTS THAT SPARKED PARTICULAR INTEREST



biochar



urine-derived
liquid products



algal
biomass

KEY OPPORTUNITIES

- more precision in nutrient application
- reducing nutrient flush to oceans
- increased future nutrient availability
- concentrated, custom-made products



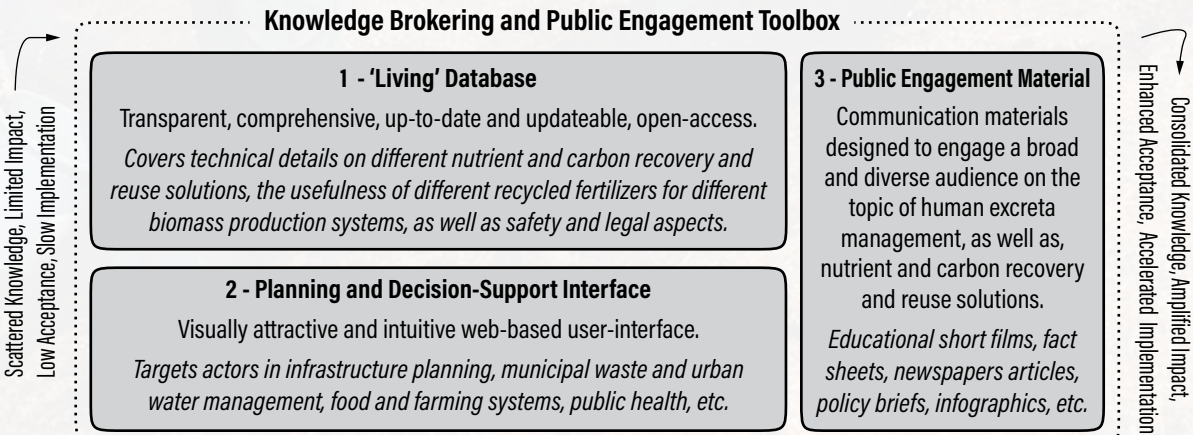
OUTLOOK

How have the interviews informed our research? What is coming next?

We were delighted by the interest producers showed in knowing more about potential future recycling fertilizers. The interviews highlighted that it is difficult for producers to find the information they would need to assess how alternative nutrient inputs could be beneficial for their farms. The producers also expressed concerns about contamination, as well as, public perception and acceptance of nutrient products derived from human excreta and wastewater. Taken together, this has motivated us to take the initiative to further collect and synthesize available best knowledge from research and practice, and to put more effort into sparking and supporting public debate on human excreta and nutrient management.

CO-CREATION OF A KNOWLEDGE BROKERING AND PUBLIC ENGAGEMENT TOOLBOX

Help various actors navigate and interpret evidence on nutrient recirculation in a structured, intuitive, and engaging manner. Includes information on the characteristics of recycled fertilizers that specifically caters to knowledge needs of producers.



Project duration: 2020 - 2023. Financial support: Kamprad Family Foundation.

THE INTERVIEWED PRODUCERS AND THEIR FARMS



10
Farms

5+5

Lower Fraser Valley
Vancouver Island

PRIMARY LAND USE
organic vegetable
production



SECONDARY LAND USES

7 farms with: fruits and berries
farm animals
wetland restoration
set-aside fields



2 to 30 years of farming experience

2 to 120 years since the farm was established



PERSPECTIVES ON FARMING

What are the main goals and objectives you have in farming and why do you continue to farm?

Which do you think are the most important factors that allow you to continue farming your land in the future?

REASONS AND MOTIVATION FOR FARMING

9 of 10
producers
mentioned

WORK AND
LIFESTYLE
ASPECTS

7
good
work love / passion for the work
gratifying / satisfying work
enjoy the work

5
good
lifestyle work where you live
living in healthy environment
good environment for children

4
flexible
work flexibility
be your own boss
do other things off-season

6 of 10
producers
mentioned

COMMUNITY AND
ENVIRONMENTAL
ASPECTS

5
food
production feed the community
produce highest quality
of food for community

2
community
education educate community
connect people to the land

2
environmental
stewardship environmental aspects
sustainability aspects
regenerate the soil

5 of 10
producers
mentioned

FINANCIAL AND
PERSONAL
ASPECTS

4
make a
living to make a living
can make a living

3
capital
lock-in well invested
can't just walk away

3
family
tradition in the genes
grew up with it

KEY FACTORS TO CONTINUE FARMING

ACCESS TO
LAND

availability of
reasonably priced
land

partnership with
First Nations

ACCESS TO
INPUTS

access to
irrigation water

access to
nutrients

less off-farm
inputs

FINANCIAL
VIABILITY

market access

community
support through
purchasing
products

ENVIRONMENTAL
VIABILITY

good soil

viable pest man-
agement

supportive
climate

PERSONAL
VIABILITY

physical health

capacity
to work

doing more
with less



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